Coastal Engineering Technical Note

Tropical Storm Database—East and Gulf of Mexico Coasts of the United States

PURPOSE: This technical note describes the availability of a database of tropical storm surge elevations and currents produced from the numerical simulation of 134 historically based events that impacted the east and Gulf of Mexico coasts of the United States. The database consists of surge data hydrographs recorded at 486 discrete locations along the east and gulf coasts and Puerto Rico. Also described are a summary atlas and cross reference tables of storm track and maximum storm surge corresponding to a 246-station nearshore subset of the 486-location database.

This database of information was generated in support of the "Long-Term Fate of Dredged Material Disposed in Open Water" research of the Dredging Research Program (DRP), which was conducted by the U.S. Army Engineer Waterways Experiment Station (WES). Although the capability to access these elevation and current time series was developed to provide input to the long-term fate and stability of dredged material model LTFATE, the potential use of such a database goes far beyond the testing of disposal site stability. The database described in this technical note can be used to provide offshore or nearshore boundary conditions for any type of coastal modeling or analysis requiring storm-generated elevation or current data.

BACKGROUND: The long-term fate research has been concerned with developing techniques to predict the long-term fate of dredged material after it has been deposited in open water on the ocean floor; that is, to address the question of whether a dredged material disposal site, either existing or proposed, is dispersive or nondispersive (Scheffner 1992). If the site is dispersive, an additional capability of the model is to estimate the rate of erosion and fate of the material. Because sediment is primarily eroded and transported as a function of waves and currents, the approach taken was to construct databases of site-specific information that could be used as input to coupled hydrodynamic, sediment transport, and bathymetry change models for predicting the long-term behavior of disposal sites. In the DRP, attention was focused on the development of the wave, tidal, and storm surge components.

The wave component of the database provides the capability for generating time series of wave height, period, and direction for any location at which a WES Wave Information Study (WIS) hindcast is available. The wave simulation capability is described in Borgman and Scheffner (1991) and Thevenot and Scheffner (1993). The tidal elevation and current components of the database are described by Westerink, Luettich, and Scheffner (1993) and Scheffner (1994). A database of extratropical storm surge elevation and current hydrographs is currently under development. This technical note describes the tropical storm surge component for the east and gulf coasts of the United States.

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HISTORIC EVENT INPUT: The tropical storm database, consisting of surge elevation and current hydrographs corresponding to selected WIS and nearshore stations along the east and gulf coasts of the United States and Puerto Rico, has been completed (Scheffner et al. 1994). The database was constructed by

numerically simulating 134 historically based hurricanes that have impacted the eastern and gulf coasts of the United States during the period 1886 to 1989. The source of data for these simulations is the National Oceanic and Atmospheric Administration's National Hurricane Center's HURDAT (HURricane DATabase), described by Jarvinen, Neumann, and Davis (1988).

The selection of storms from the HURDAT was based on the selection of events that impacted each of eight coastal segments along the east and gulf coasts of the United States, described by Ho et al. (1987). These eight regions were defined to have a homogeneous population of events such that storm parameters associated with events for one location in the segment appear similar to the parameters associated with another location within the segment. A thorough analysis of the selection process and procedures is presented in Ho et al. (1987).

The selection of events for inclusion in the database was made by defining a latitude and longitude rectangle encompassing each of the segments. These rectangular regions are shown in Figure 1. The tracks of all 875 events in the 1886-1989 edition of the HURDAT file were examined to determine if they entered the segment rectangle. Of those that did enter the rectangle, those events whose minimum central pressure was greater than 995 mb, those whose track was only on the landward side of the rectangle, and those that were far from the shoreline near the seaward boundary were discarded. This process of elimination resulted in the selection of the following number of events associated with each rectangle: 1 - 27; 2 - 35; 3 - 29; 4 - 33; 5 - 55; 6 - 52; 7 - 30; and 8 - 21.

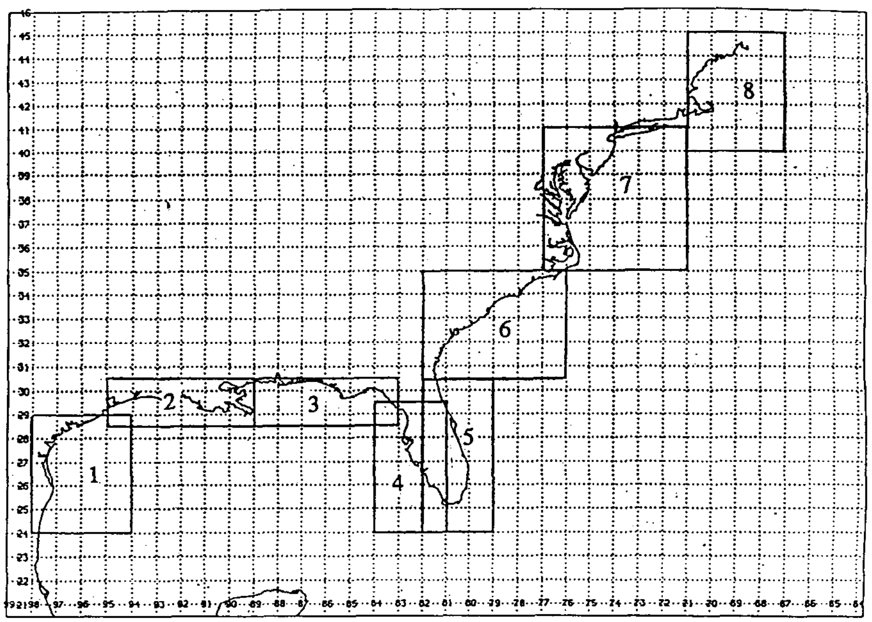


Figure 1. Coastal segment rectangles

Because many of the events impacted two or more segments, numerous redundancies were identified in the segment-by-segment selection of events. After removing duplications, 134 events were selected for use in the modeling simulation process. These selected events are listed in chronological order in Figure 2 according to date of inception, corresponding HURDAT number, and given name.

<u>DATABASE OUTPUT STATION LOCATIONS</u>: The goal of this database was to provide boundary condition data for any coastal application requiring either surge elevation or current information along the east and gulf coasts of the United States. To accomplish this task and have the database remain tractable with respect to

memory requirements, discrete locations for archiving data were defined according to two criteria. First, output locations were selected to correspond to the 240 east and gulf coast WIS stations (Hubertz et al. 1993), with additional locations prescribed for Puerto Rico. These stations are located at every 0.25 deg of latitude and longitude along the coastline in water depths averaging between 10 and 20 m. Because WIS stations are located at variable distances from the shoreline, 246 additional locations were selected to represent nearshore projections of WIS stations, resulting in a total of 486 discrete locations at which surge elevation and current hydrograph information are archived. Detailed figures of these locations, their respective station numbers, latitude and longitude location, and approximate depth, and the sum of eight primary tidal elevation constituents extracted from the DRP tidal database are given in Scheffner et al. (1994).

1	8/12/1886	HURDAT # 5	NOT NAMED
2	8/15/1893	HURDAT # 72	NOT NAMED
3	9/27/1893	HURDAT # 76	NOT NAMED
4	9/22/1896	HURDAT # 94	NOT NAMED
5	8/30/1898	HURDAT # 103	NOT NAMED
6	8/ 3/1899	HURDAT # 112	NOT NAMED
7	8/27/1900	HURDAT # 117	NOT NAMED
8	8/ 4/1901	HURDAT # 127	NOT NAMED
9	9/ 9/1903	HURDAT # 141	NOT NAMED
10	7/13/1909	HURDAT # 183	NOT NAMED
11	9/10/1909	HURDAT # 187	NOT NAMED
12	10/ 6/1909	HURDAT # 189	NOT NAMED
13	10/ 9/1910	HURDAT # 194	NOT NAMED
14	8/23/1911	HURDAT # 196	NOT NAMED
15	8/ 5/1915	HURDAT # 211	NOT NAMED
16	9/22/1915	HURDAT # 214	NOT NAMED
17	6/29/1916	HURDAT # 215	NOT NAMED
18	7/11/1916	HURDAT # 217	NOT NAMED
19	8/12/1916	HURDAT # 218	NOT NAMED
20	10/12/1916	HURDAT # 227	NOT NAMED
21	9/21/1917	HURDAT # 231	NOT NAMED
22	8/ 1/1918	HURDAT # 232	NOT NAMED
23	9/16/1920	HURDAT # 241	NOT NAMED
24	10/20/1921	HURDAT # 249	NOT NAMED
25	7/22/1926	HURDAT # 271	NOT NAMED
26	9/11/1926	HURDAT # 276	NOT NAMED
27	8/ 3/1928	HURDAT # 289	NOT NAMED
28	9/ 6/1928	HURDAT # 292	NOT NAMED
29	6/27/1929	HURDAT # 295	NOT NAMED
30	9/22/1929	HURDAT # 296	NOT NAMED
31	8/31/1930	HURDAT # 299	NOT NAMED
32	8/12/1932	HURDAT # 310	NOT NAMED
33	7/25/1933	HURDAT # 324	NOT NAMED
34	8/17/1933	HURDAT # 327	NOT NAMED
35	8/31/1933	HURDAT # 331	NOT NAMED
36	9/ 8/1933	HURDAT # 332	NOT NAMED
37	8/29/1935	HURDAT # 353	NOT NAMED
38	10/30/1935	HURDAT # 357	NOT NAMED
39	7/27/1936	HURDAT # 362	NOT NAMED
40	9/ 8/1936	HURDAT # 370	NOT NAMED
41	9/10/1938	[illegible] # 386	NOT NAMED
42	8/ 2/1[illegible]	[illegible] # 397	NOT NAMED
43	8/ 5/[illegible]	[illegible] # 398	NOT NAMED
44	9/16/1[illegible]	[illegible] 405	NOT NAMED
45	7/30/194[illegible]	[illegible] 132	NOT NAMED
46	9/ 9/1944	[illegible] # 436	NOT NAMED
47	10/12/1944	HUR[illegible]T # 440	NOT NAMED
48	8/24/1945	HURDAT # 445	NOT NAMED
49	9/12/1945	HURDAT # 449	NOT NAMED
50	10/ 5/1946	HURDAT # 456	NOT NAMED
51	9/ 4/1947	HURDAT # 461	NOT NAMED
52	9/20/1947	HURDAT # 463	NOT NAMED
53	10/ 9/1947	HURDAT # 465	NOT NAMED
54	9/ 1/1948	HURDAT # 471	NOT NAMED
55	9/18/1948	HURDAT # 473	NOT NAMED
56	10/ 3/1948	HURDAT # 474	NOT NAMED
57	8/23/1949	HURDAT # 477	NOT NAMED
58	8/20/1950	HURDAT # 490	BAKER
59	9/ 1/1950	HURDAT # 493	EASY
60	10/13/1950	HURDAT # 499	KING
61	8/11/1953	HURDAT # 520	BARBARA
62	8/28/1953	HURDAT # 521	NOT NAMED
63	8/28/1953	HURDAT # 522	CAROL
64	9/23/1953	HURDAT # 526	FLORENCE
65	10/ 7/1953	HURDAT # 530	HAZEL
66	8/25/1954	HURDAT # 535	CAROL
67	10/ 5/1954	HURDAT # 541	HAZEL
68	8/ 3/1955	HURDAT # 545	CONNIE
69	8/ 7/1955	HURDAT # 546	DIANE
70	9/10/1955	HURDAT # 552	IONE
71	9/21/1956	HURDAT # 562	FLOSSY
72	6/25/1957	HURDAT # 565	AUDREY
73	8/24/1958	HURDAT # 575	DAISY
74	6/18/1959	HURDAT # 584	NOT NAMED
75	7/23/1959	HURDAT # 586	DEBRA
76	9/20/1959	HURDAT # 589	GRACIE
77	8/29/1960	HURDAT # 597	DONNA
78	9/14/1960	HURDAT # 598	ETHEL
79	9/ 3/1961	HURDAT # 602	CARLA
80	9/10/1961	HURDAT # 604	ESTHER
81	9/30/1961	HURDAT # 606	FRANCES
82	8/26/1962	HURDAT # 611	ALMA
83	10/16/1963	HURDAT # 623	GINNY
84	8/20/1964	HURDAT # 629	CLEO
85	8/28/1964	HURDAT # 630	DORA
86	9/28/1964	HURDAT # 634	HILDA
87	10/ 8/1964	HURDAT # 635	ISBELL
88	8/27/1965	HURDAT # 639	BETSY
89	6/ 4/1966	HURDAT # 643	ALMA
90	9/21/1966	HURDAT # 651	INEZ
91	9/ 8/1967	HURDAT # 657	DORIA
92	6/ 1/1968	HURDAT # 662	ABBY
93	10/13/1968	HURDAT # 669	GLADYS
94	8/14/1969	HURDAT # 672	CAMILLE
95	9/ 6/1969	HURDAT # 676	GERDA
96	5/17/1970	HURDAT # 688	ALMA
97	7/31/1970	HURDAT # 690	CELIA
98	9/ 8/1970	HURDAT # 693	ELLA
99	8/20/1971	HURDAT # 702	DORIA
100	9/ 5/1971	HURDAT # 703	EDITH
101	9/ 3/1971	HURDAT # 704	FERN
102	5/23/1972	HURDAT # 711	ALPHA
103	6/14/1972	HURDAT # 712	AGNES
104	9/ 1/1973	HURDAT # 722	DELIA
105	6/29/197[illegible]	HURDAT # 731	CARMEN
106	[illegible]/14/1975	HURDAT # 739	CAROLINE
107	9/13/1975	HURDAT # 741	ELOISE
108	5/21/1976	HURDAT # 746	SUBTROP 1
109	8/ 6/1976	HURDAT # 748	BELLE
110	8/29/1977	HURDAT # 756	ANITA
111	9/ 3/1977	HURDAT # 757	BABE
112	7/ 9/1979	HURDAT # 775	BOB
113	8/25/1979	HURDAT # 777	DAVID
114	8/29/1979	HURDAT # 779	FREDERIC
115	7/31/1980	HURDAT # 783	ALLEN
116	8/ 7/1981	HURDAT # 797	DENNIS
117	11/12/1981	HURDAT # 805	SUBTROP 3
118	6/18/1982	HURDAT # 807	SUBTROP 1
119	9/ 9/1982	HURDAT # 809	CHRIS
120	8/15/1983	HURDAT # 812	ALICIA
121	8/23/1983	HURDAT # 813	BARRY
122	9/ 8/1984	HURDAT # 820	DIANA
123	8/12/1985	HURDAT # 832	DANNY
124	8/28/1985	HURDAT # 833	ELENA
125	9/16/1985	HURDAT # 835	GLORIA
126	10/26/1985	HURDAT # 838	JUAN
127	11/15/1985	HURDAT # 839	KATE
128	6/23/1986	HURDAT # 841	BONNIE
129	10/ 9/1987	HURDAT # 852	FLOYD
130	9/ 7/1988	HURDAT # 859	FLORENCE
131	11/17/1988	HURDAT # 864	KEITH
132	7/30/1989	HURDAT # 867	CHANTAL
133	9/10/1989	HURDAT # 872	HUGO
134	10/12/1989	HURDAT # 874	JERRY

Figure 2. Historical tropical storm database

TROPICAL STORM DATABASE: All 134 tropical events selected for the database were simulated in their entirety, with output files initially archived for all 486 WIS and nearshore projected stations. The finite element-based hydrodynamic model ADCIRC-2DDI (Luettich, Westerink, and Scheffner 1992) was used for all storm event simulations. A very large computational domain, shown in Figure 3, is used for modeling the storm events selected as the basis for this database. The modeled area includes the western North Atlantic ocean, the Gulf of Mexico, and the Caribbean Sea. This domain was initially developed for tidal propagation studies (Westerink, Luettich, and Scheffner 1993). However, its implementation for storm propagation has been demonstrated through accurate predictions of both the primary storm surge and the surge forerunner effect (Blain, Westerink, and Luettich, in preparation).

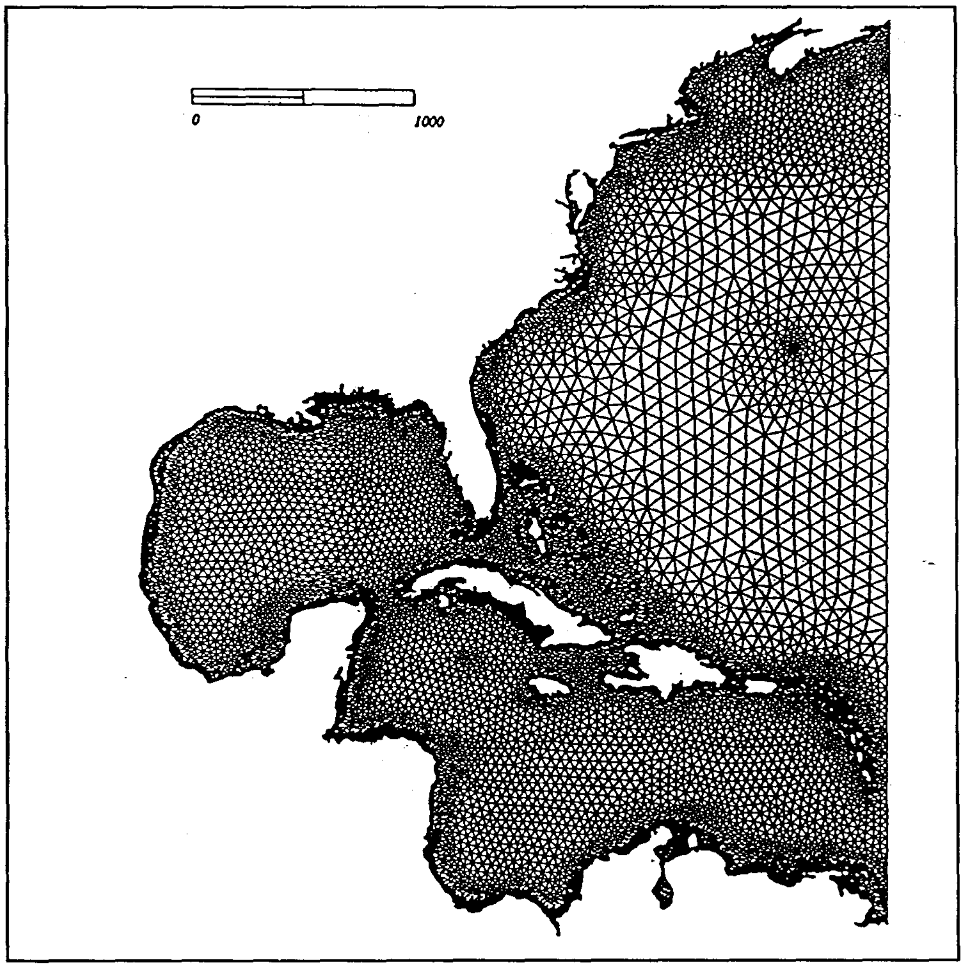


Figure 3. East coast, Gulf of Mexico, and Caribbean Sea computational domain

Because each hurricane event does not impact every coastal station, the database described in this technical note and presented in Scheffner et al. (1994) was constructed such that surge information was archived only for locations at which a maximum surge elevation of 1 ft (0.3048 m) or greater was computed. To eliminate possible start-up or termination transients or far-field discontinuities that may propagate beyond the edge of the nested PBL model, potential impacted stations were also required to be within a 200-mile (320-km) radius of the eye of the storm. The reported maximum surge was selected as the maximum elevation on the surge water surface hydrograph in a ± 6-hr window from the time (nearest hour) when the hurricane eye is nearest to the

selected station. A summary of the full database is provided by Scheffner et al. (1994), in the form of an atlas of maximum storm surge elevations computed at each WIS/nearshore station subject to the above limitations. The maximum surge atlas and the surge elevation and current database are briefly described below.

Surge Maximum Elevation Atlas: The atlas of the nearshore spatial distribution of maximum surge elevation was generated as a tool for identifying storms that impacted specific locations along the east and gulf coast areas and offshore of Puerto Rico. A typical component of the atlas is shown in Figure 4 for Hurricane Bonnie. This figure contains a summary plot of the total storm track according to the information contained in the HURDAT database, as well as a landfall or near landfall map enlargement detailing the spatial distribution of maximum surge magnitudes.

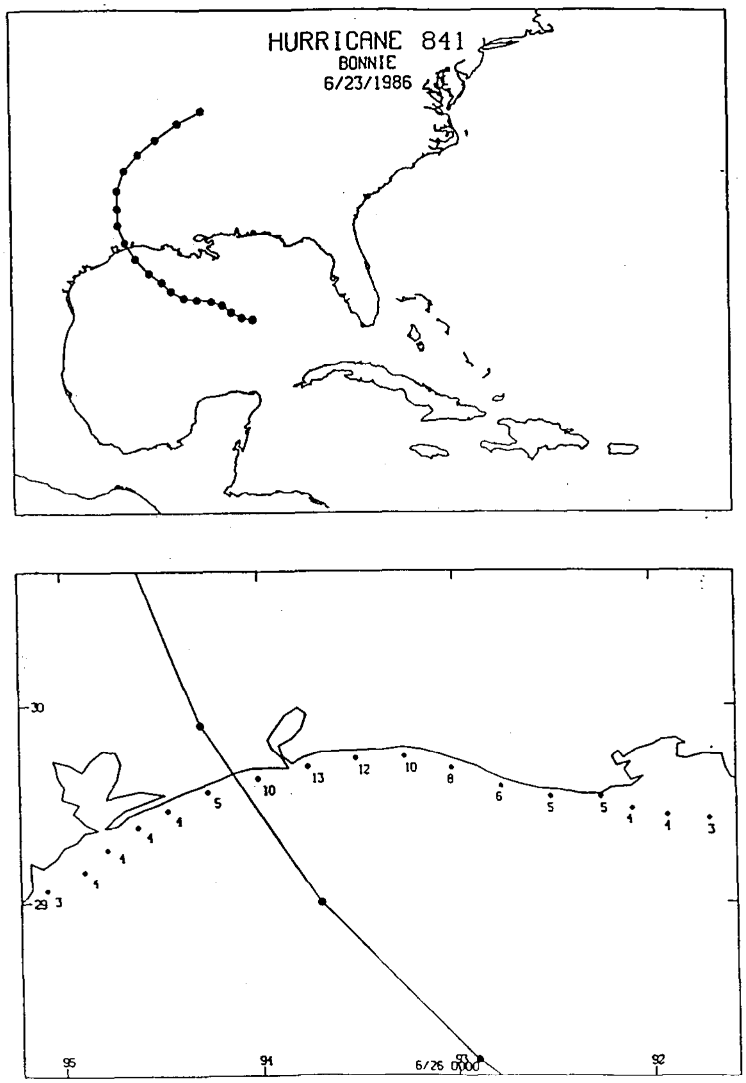


Figure 4. Track and surge atlas for Hurricane Bonnie

To maximize the readability by reducing the density of information contained in the atlas, surge elevations are reported in decimeters (10 dm = 1 m). For example, the maximum surge for Hurricane Bonnie in Figure 4 is shown to be 13 dm (1.3 m) at the second nearshore station to the east of landfall. The location map and a portion of the station descriptor contained in Scheffner et al. (1994) are reproduced as Figure 5. This information is used to identify the station number, location, approximate spring tide amplitude, and approximate depth. For the example shown in Figure 4, the nearshore station can be identified as station 539, located at 93.7569 deg west longitude, 29.6873 deg north latitude, with an approximate spring tide amplitude of 0.8435 m and an approximate depth of 6.5 m.

Cross-referencing of the summary database of storm-specific maximum surge elevations for the nearshore gauges is provided in the report so that users can determine the spatial alongshore impact of each historic event, and also determine which historic events impacted a specific WIS/ nearshore station. This information is presented in a two-sequence tabular form, with the first portion containing the HURDAT storm number and the number of WIS/nearshore stations that were impacted by that storm event (limited to a minimum surge of 1 ft and located within 200 miles of the eye of the event), followed by a tabulation of stations impacted and their respective maximum surge elevations in decimeters. Figure 6 presents an extracted example for HURDAT No. 841 (Hurricane Bonnie). As shown, event 841 impacted 31 WIS/nearshore stations, with station 539 showing a maximum surge of 13 dm.

The second portion of the index presents a tabulation of events that impacted each specific WIS/nearshore station and the surge produced by that storm. For example, Figure 7 presents an example listing for nearshore station 539. As shown in the table, station 539 was impacted by 25 tropical events, with HURDAT No. 841 producing a maximum surge elevation of 13 dm.

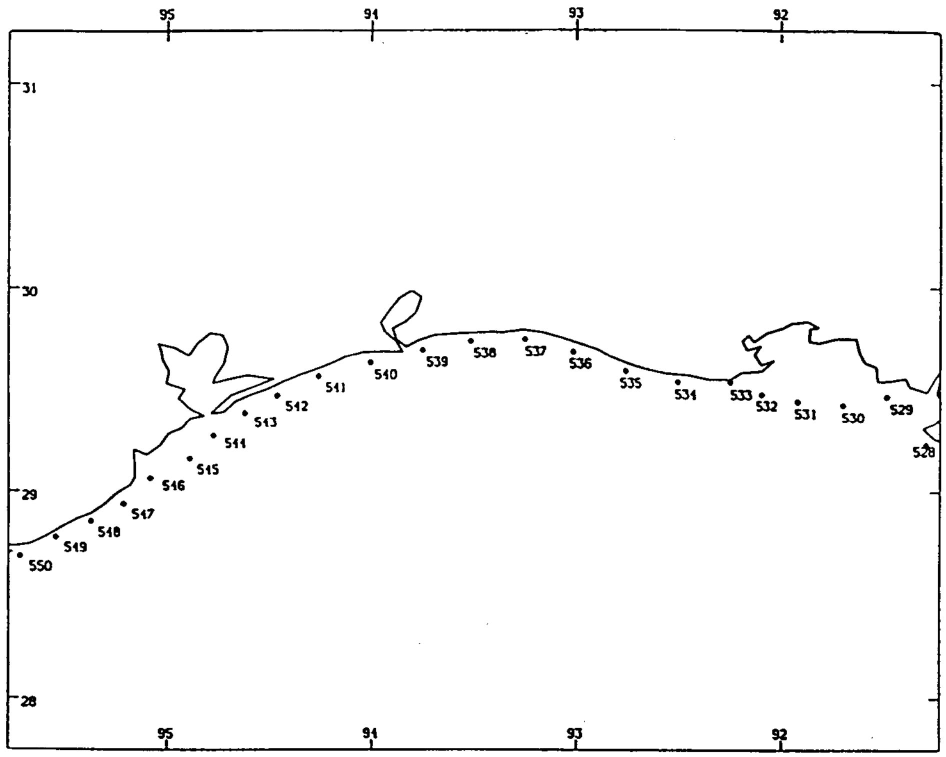
The purpose of the atlas and accompanying indexed surge data is to provide a comprehensive listing of storms, their areas of impact, and their intensity as measured by their maximum surge. These data can then be used to identify and access the WIS/nearshore database of tropical events for use as surge elevation and current boundary conditions.

SURGE ELEVATION AND CURRENT DATABASE: The storm elevation and current hydrograph database for both nearshore and WIS stations is available through the Coastal Engineering Research Center at WES. The database consists of 134 separate files, each containing the surface elevation (in meters), the *U* velocity (east in meters per second), and the *V* velocity (north in meters per second) at a 15-min increment for each impacted WIS and nearshore station along the United States east and gulf coasts and for selected locations offshore of Puerto Rico.

Each file begins with header information containing the HURDAT storm number, start time, duration of the event in hours, hydrograph start time (storm start + 15 min), number of points, and time interval between points. The storm identification data are followed by a tabulation for each impacted WIS or nearshore station, which contains the station identification number and sequential listings of time series of surface elevation, *U* and *V* velocity components. The example header file and station file corresponding to nearshore station 539 are presented as Figure 8. A plot of the data listed in Figure 8 is shown as Figure 9.

As evidenced from the examples presented in this technical note, the tropical event database described in Scheffner et al. (1994) is highly informative, easily accessible, and can be used for a variety of preliminary or detailed coastal evaluations of storm intensity and storm impact. This database represents a unique assembly of offshore and nearshore elevation and current time series data that are not available from any single source.

CONCLUSIONS: This technical note describes the availability of a database of tropical storm surge elevation and current hydrograph time series that can be used as boundary conditions for evaluating the fate and stability



Station	Latitude	Longitude	Spring tide Amplitude (m)	Depth (m)
520	-89.56350	29.07680	0.45584	20.05766
521	-89.75130	29.23040	0.46266	9.55403
522	-90.00160	29.21340	0.46487	6.98934
523	-90.24150	29.06830	0.47008	9.18662
524	-90.53360	29.21340	0.50082	8.96870
525	-90.76310	29.08540	0.51362	8.78566
526	-91.01350	29.14980	0.55416	6.63064
527	-91.19080	29.16690	0.58888	5.38724
528	-91.31600	29.22660	0.62024	4.62138
529	-91.50370	29.46550	0.64680	6.71694
530	-91.71230	29.42280	0.62417	4.00000
531	-91.92100	29.43990	0.66267	4.00000
532	-92.09830	29.47400	0.68786	4.43894
533	-92.25480	29.53380	0.68941	4.14046
534	-92.50510	29.53380	0.72280	6.21479
535	-92.76590	29.58500	0.76584	7.57567
536	-93.01620	29.67880	0.80926	6.49206
537	-93.25620	29.73850	0.83335	7.12591
538	-93.51690	29.73000	0.84829	4.86125
539	-93.75690	29.68730	0.84350	6.47503
540	-94.00720	29.62760	0.82655	5.76917

Figure 5. Sample locator map and station description

No. Impacted

HURDAT STORM 841, # STATIONS-MAX SURGE 31
133- 3 134- 4 135- 4 136- 4 137- 5 138- 7 139- 8 140- 8 141- 7 142- 6 143- 5 144- 5 145- 5 146- 3 530- 3
531- 4 532- 4 533- 5 534- 5 535- 6 536- 8 537-10 538-12 539-13 540-10 541- 5 542- 4 543- 4 544- 4 545- 4
546- 3

WIS Station No.

Maximum Surge (dm)

Figure 6. WIS/nearshore stations impacted by HURDAT No. 841

WIS/NEARSHORE STATION 539, # HURDAT STORMS-MAX SURGE 25
5- 4 117-23 183-10 211-36 232-14 295- 4 310-54 324- 5 397-15 405-23 445-11 565-26 586-10 602-22 690- 8
703- 9 704- 5 722-18 731- 6 809-17 812-24 832- 3 841-13 867-16 874-13

Figure 7. HURDAT events impacting WIS/nearshore station 539

HURRDAT STORM NUMBER: 841
STORM START TIME (YR/MO/DAY/HOUR): 1986/ 6/23/18, #HRS = 114
HYDROGRAPH START TIME (YR/MO/DAY/HOUR): 1986/ 6/23/18.25, #PTS = 456 AT 15.0 MIN INCR
STATION: 539 LONGITUDE,LATITUDE: -93.7570 29.6870
SURFACE ELEVATION (M)

0.001	0.001	0.002	0.003	0.004	0.005	0.006	0.008	0.009	0.011	0.012	0.014	0.016	0.019	0.022	0.025
0.028	0.032	0.036	0.040	0.043	0.047	0.052	0.057	0.061	0.064	0.067	0.069	0.071	0.073	0.075	0.078
0.081	0.083	0.086	0.088	0.091	0.094	0.096	0.098	0.101	0.103	0.106	0.108	0.110	0.113	0.115	0.118
0.119	0.120	0.121	0.121	0.121	0.121	0.122	0.122	0.123	0.125	0.126	0.128	0.130	0.133	0.135	0.137
0.138	0.140	0.141	0.142	0.143	0.143	0.143	0.144	0.143	0.143	0.143	0.142	0.142	0.141	0.140	0.139
0.138	0.137	0.136	0.135	0.133	0.132	0.130	0.128	0.126	0.124	0.122	0.119	0.117	0.116	0.114	0.112
0.110	0.109	0.108	0.107	0.106	0.106	0.106	0.106	0.107	0.108	0.109	0.111	0.112	0.114	0.115	0.116
0.118	0.119	0.120	0.120	0.121	0.122	0.123	0.124	0.124	0.126	0.127	0.128	0.130	0.132	0.135	0.137
0.139	0.142	0.145	0.149	0.152	0.156	0.160	0.164	0.168	0.173	0.176	0.180	0.184	0.188	0.193	0.197
0.202	0.207	0.211	0.216	0.220	0.225	0.229	0.233	0.237	0.240	0.243	0.247	0.250	0.254	0.256	0.259
0.261	0.263	0.266	0.269	0.271	0.274	0.276	0.278	0.280	0.282	0.283	0.284	0.285	0.286	0.288	0.289
0.291	0.294	0.296	0.298	0.301	0.303	0.306	0.309	0.312	0.315	0.317	0.319	0.321	0.324	0.326	0.328
0.329	0.331	0.332	0.334	0.336	0.338	0.339	0.340	0.340	0.340	0.340	0.340	0.340	0.339	0.338	0.337
0.337	0.338	0.340	0.340	0.341	0.341	0.342	0.342	0.343	0.344	0.345	0.346	0.348	0.351	0.353	0.356
0.359	0.362	0.366	0.373	0.381	0.388	0.395	0.401	0.406	0.413	0.421	0.429	0.439	0.451	0.463	0.478
0.494	0.511	0.533	0.557	0.584	0.618	0.661	0.708	0.762	0.826	0.897	0.972	1.049	1.121	1.187	1.244
1.286	1.304	1.299	1.278	1.242	1.193	1.133	1.069	1.003	0.938	0.877	0.817	0.763	0.715	0.673	0.634
0.599	0.569	0.543	0.519	0.497	0.477	0.459	0.444	0.431	0.420	0.409	0.400	0.391	0.385	0.380	0.377
0.375	0.373	0.368	0.360	0.351	0.340	0.329	0.318	0.308	0.297	0.286	0.276	0.265	0.255	0.244	0.233
0.220	0.207	0.195	0.182	0.168	0.153	0.138	0.121	0.102	0.083	0.063	0.043	0.024	0.006	-0.011	-0.025
-0.036	-0.044	-0.049	-0.052	-0.051	-0.048	-0.042	-0.032	-0.020	-0.005	0.011	0.028	0.045	0.060	0.075	0.089
0.102	0.114	0.124	0.132	0.138	0.142	0.144	0.143	0.141	0.137	0.131	0.123	0.114	0.104	0.094	0.083
0.072	0.062	0.051	0.040	0.030	0.020	0.011	0.002	-0.005	-0.011	-0.015	-0.018	-0.020	-0.020	-0.019	-0.016
-0.013	-0.008	-0.002	0.004	0.012	0.020	0.029	0.038	0.047	0.056	0.065	0.074	0.081	0.088	0.094	0.098
0.100	0.100	0.099	0.096	0.091	0.086	0.080	0.073	0.066	0.059	0.052	0.045	0.039	0.033	0.027	0.022
0.017	0.011	0.006	0.001	-0.004	-0.009	-0.012	-0.015	-0.016	-0.017	-0.016	-0.015	-0.013	-0.011	-0.008	-0.004
0.000	0.005	0.010	0.015	0.020	0.026	0.030	0.035	0.038	0.041	0.043	0.044	0.044	0.044	0.042	0.040
0.037	0.033	0.028	0.023	0.018	0.012	0.006	0.000	-0.006	-0.012	-0.018	-0.023	-0.028	-0.033	-0.037	-0.040
-0.043	-0.045	-0.046	-0.047	-0.047	-0.046	-0.045	-0.044								

Figure 8. Database representation of HURDAT No. 841, nearshore station 539 (Continued)

U (EAST) VELOCITY (M/SEC)

-0.004	-0.008	-0.013	-0.017	-0.021	-0.025	-0.029	-0.033	-0.036	-0.039	-0.042	-0.045	-0.047	-0.050	-0.052	-0.055
-0.057	-0.060	-0.063	-0.065	-0.068	-0.071	-0.073	-0.075	-0.077	-0.080	-0.083	-0.085	-0.087	-0.089	-0.090	-0.092
-0.093	-0.094	-0.095	-0.096	-0.097	-0.098	-0.099	-0.099	-0.099	-0.099	-0.099	-0.099	-0.098	-0.098	-0.098	-0.097
-0.097	-0.097	-0.098	-0.098	-0.099	-0.100	-0.101	-0.102	-0.103	-0.103	-0.104	-0.104	-0.104	-0.105	-0.105	-0.106
-0.106	-0.107	-0.108	-0.108	-0.109	-0.110	-0.112	-0.113	-0.114	-0.114	-0.115	-0.115	-0.116	-0.116	-0.116	-0.115
-0.115	-0.115	-0.115	-0.115	-0.115	-0.115	-0.116	-0.116	-0.117	-0.117	-0.118	-0.119	-0.120	-0.121	-0.122	-0.123
-0.124	-0.125	-0.126	-0.127	-0.128	-0.129	-0.129	-0.129	-0.130	-0.130	-0.130	-0.131	-0.131	-0.132	-0.133	-0.133
-0.134	-0.135	-0.136	-0.138	-0.139	-0.140	-0.141	-0.142	-0.143	-0.144	-0.144	-0.145	-0.145	-0.145	-0.145	-0.145
-0.145	-0.145	-0.144	-0.144	-0.144	-0.144	-0.144	-0.144	-0.144	-0.144	-0.144	-0.144	-0.144	-0.145	-0.145	-0.145
-0.146	-0.146	-0.146	-0.147	-0.147	-0.148	-0.148	-0.149	-0.150	-0.151	-0.151	-0.152	-0.152	-0.152	-0.152	-0.152
-0.152	-0.152	-0.152	-0.152	-0.152	-0.152	-0.152	-0.152	-0.153	-0.153	-0.154	-0.154	-0.154	-0.155	-0.155	-0.155
-0.155	-0.155	-0.155	-0.155	-0.155	-0.155	-0.155	-0.155	-0.155	-0.156	-0.156	-0.156	-0.156	-0.156	-0.156	-0.156
-0.156	-0.156	-0.156	-0.156	-0.156	-0.156	-0.157	-0.157	-0.158	-0.158	-0.159	-0.160	-0.160	-0.161	-0.161	-0.162
-0.163	-0.163	-0.164	-0.166	-0.167	-0.169	-0.171	-0.173	-0.175	-0.178	-0.181	-0.184	-0.187	-0.191	-0.195	-0.199
-0.203	-0.208	-0.214	-0.221	-0.228	-0.236	-0.245	-0.255	-0.266	-0.279	-0.292	-0.306	-0.322	-0.340	-0.361	-0.382
-0.407	-0.436	-0.466	-0.498	-0.530	-0.563	-0.593	-0.622	-0.648	-0.670	-0.689	-0.705	-0.706	-0.688	-0.662	-0.632
-0.595	-0.552	-0.508	-0.464	-0.425	-0.394	-0.365	-0.333	-0.302	-0.274	-0.245	-0.215	-0.184	-0.152	-0.120	-0.086
-0.052	-0.017	0.017	0.048	0.076	0.101	0.121	0.137	0.150	0.159	0.166	0.170	0.172	0.173	0.174	0.174
0.173	0.168	0.163	0.156	0.149	0.142	0.135	0.130	0.125	0.122	0.120	0.119	0.120	0.122	0.125	0.128
0.131	0.134	0.136	0.137	0.137	0.136	0.133	0.130	0.126	0.122	0.117	0.112	0.107	0.102	0.098	0.093
0.088	0.083	0.078	0.073	0.068	0.063	0.059	0.056	0.052	0.050	0.047	0.045	0.042	0.040	0.038	0.036
0.033	0.030	0.027	0.023	0.019	0.014	0.008	0.003	-0.002	-0.007	-0.011	-0.015	-0.017	-0.019	-0.020	-0.019
-0.018	-0.016	-0.013	-0.009	-0.005	-0.001	0.004	0.008	0.012	0.016	0.020	0.022	0.024	0.026	0.027	0.027
0.027	0.026	0.025	0.023	0.022	0.020	0.019	0.018	0.017	0.017	0.017	0.018	0.020	0.022	0.024	0.026
0.029	0.031	0.033	0.035	0.037	0.040	0.043	0.045	0.049	0.052	0.056	0.060	0.063	0.066	0.069	0.072
0.073	0.074	0.075	0.076	0.076	0.076	0.076	0.076	0.077	0.078	0.079	0.080	0.082	0.083	0.084	0.085
0.086	0.087	0.087	0.088	0.088	0.087	0.087	0.086	0.085	0.084	0.083	0.082	0.082	0.081	0.081	0.081
0.081	0.082	0.083	0.084	0.085	0.086	0.088	0.089	0.091	0.093	0.094	0.095	0.096	0.097	0.098	0.098
0.098	0.098	0.097	0.097	0.096	0.095	0.095	0.094								

V (NORTH) VELOCITY (M/SEC)

-0.002	-0.004	-0.006	-0.008	-0.010	-0.012	-0.013	-0.015	-0.017	-0.018	-0.020	-0.021	-0.022	-0.023	-0.024	-0.025
-0.026	-0.027	-0.028	-0.030	-0.031	-0.031	-0.032	-0.033	-0.034	-0.036	-0.038	-0.039	-0.040	-0.040	-0.041	-0.041
-0.041	-0.041	-0.042	-0.042	-0.043	-0.043	-0.044	-0.044	-0.044	-0.044	-0.043	-0.043	-0.043	-0.043	-0.043	-0.043
-0.043	-0.043	-0.044	-0.044	-0.045	-0.045	-0.046	-0.046	-0.046	-0.046	-0.046	-0.046	-0.046	-0.046	-0.046	-0.047
-0.047	-0.048	-0.048	-0.049	-0.049	-0.050	-0.051	-0.051	-0.052	-0.052	-0.053	-0.053	-0.053	-0.053	-0.053	-0.053
-0.053	-0.053	-0.053	-0.053	-0.054	-0.054	-0.054	-0.054	-0.055	-0.055	-0.056	-0.056	-0.056	-0.057	-0.057	-0.057
-0.058	-0.058	-0.059	-0.059	-0.059	-0.059	-0.059	-0.059	-0.059	-0.059	-0.059	-0.059	-0.059	-0.059	-0.060	-0.060
-0.061	-0.061	-0.062	-0.062	-0.063	-0.063	-0.064	-0.064	-0.065	-0.065	-0.065	-0.065	-0.064	-0.064	-0.064	-0.064
-0.064	-0.063	-0.063	-0.063	-0.063	-0.063	-0.062	-0.062	-0.062	-0.062	-0.062	-0.062	-0.062	-0.062	-0.062	-0.062
-0.062	-0.062	-0.063	-0.063	-0.063	-0.063	-0.064	-0.064	-0.065	-0.065	-0.065	-0.066	-0.066	-0.066	-0.066	-0.066
-0.066	-0.066	-0.066	-0.066	-0.066	-0.066	-0.066	-0.066	-0.067	-0.067	-0.068	-0.068	-0.068	-0.068	-0.068	-0.068
-0.068	-0.067	-0.067	-0.067	-0.068	-0.067	-0.067	-0.067	-0.067	-0.067	-0.068	-0.068	-0.068	-0.068	-0.068	-0.068
-0.068	-0.068	-0.068	-0.068	-0.068	-0.068	-0.069	-0.070	-0.070	-0.071	-0.071	-0.071	-0.072	-0.072	-0.073	-0.072
-0.072	-0.072	-0.072	-0.074	-0.075	-0.075	-0.076	-0.077	-0.078	-0.079	-0.081	-0.082	-0.082	-0.084	-0.085	-0.087
-0.089	-0.091	-0.092	-0.094	-0.096	-0.101	-0.106	-0.110	-0.115	-0.120	-0.124	-0.130	-0.135	-0.142	-0.149	-0.157
-0.165	-0.175	-0.185	-0.195	-0.204	-0.210	-0.215	-0.222	-0.224	-0.224	-0.225	-0.227	-0.224	-0.218	-0.211	-0.204
-0.202	-0.201	-0.195	-0.186	-0.178	-0.174	-0.168	-0.158	-0.145	-0.133	-0.120	-0.106	-0.090	-0.073	-0.057	-0.040
-0.023	-0.005	0.011	0.026	0.038	0.049	0.058	0.065	0.070	0.074	0.075	0.076	0.078	0.079	0.080	0.081
0.079	0.075	0.070	0.065	0.061	0.057	0.054	0.051	0.049	0.047	0.046	0.045	0.045	0.046	0.047	0.047
0.047	0.048	0.049	0.049	0.048	0.046	0.044	0.042	0.039	0.037	0.034	0.033	0.031	0.030	0.030	0.030
0.030	0.030	0.030	0.030	0.030	0.029	0.030	0.030	0.031	0.031	0.031	0.030	0.029	0.027	0.026	0.024
0.022	0.020	0.018	0.014	0.011	0.007	0.003	-0.001	-0.005	-0.008	-0.011	-0.014	-0.016	-0.017	-0.017	-0.017
-0.016	-0.015	-0.014	-0.012	-0.010	-0.007	-0.004	-0.001	0.002	0.004	0.007	0.009	0.012	0.013	0.015	0.016
0.017	0.017	0.018	0.018	0.018	0.018	0.018	0.017	0.017	0.017	0.017	0.017	0.017	0.018	0.018	0.018
0.018	0.018	0.018	0.018	0.018	0.018	0.019	0.020	0.021	0.022	0.024	0.026	0.028	0.029	0.030	0.031
0.032	0.032	0.032	0.033	0.033	0.033	0.034	0.034	0.035	0.036	0.037	0.038	0.039	0.040	0.041	0.042
0.043	0.043	0.044	0.044	0.044	0.043	0.043	0.042	0.041	0.040	0.039	0.038	0.037	0.037	0.036	0.035
0.035	0.035	0.035	0.035	0.035	0.036	0.036	0.037	0.038	0.039	0.039	0.040	0.041	0.042	0.042	0.043
0.043	0.043	0.044	0.044	0.044	0.044	0.044	0.044								

Figure 8. Database representation of HURDAT No. 841, nearshore station 539 (Concluded)

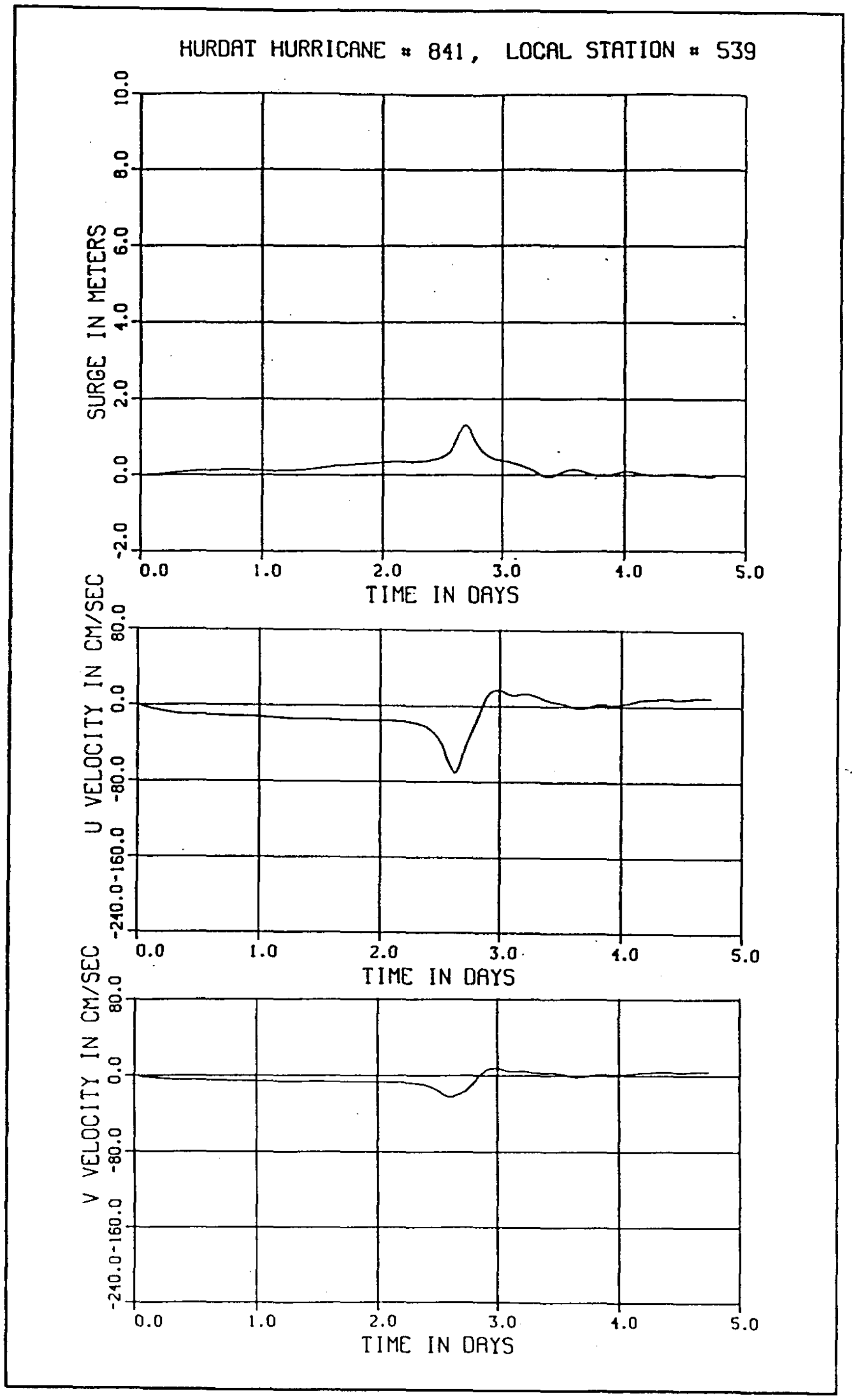


Figure 9. Hydrograph time series plot of data listed in Figure 8

of dredged material disposed in open water. Data were numerically generated in response to 134 historically based tropical storms that impacted the east and gulf coasts of the United States. Data are archived at 486 discrete locations along the east and gulf coasts of the United States and for selected locations around the island of Puerto Rico.

Because tides are not included in the simulations and storm parameters were not optimized to prototype conditions, the selected storms are not intended to be hindcasts of specific events. Rather, the simulated events are intended to approximate a number of historically based storms in order to generate a database of responses that are realistic in both magnitude, duration, and shape.

The tropical storm database for the east coast and Gulf of Mexico described in this technical note satisfies the original goal of the project; that is, to provide boundary condition data for disposal site analysis. Additionally, the database represents a very comprehensive and realistic database of storm data that can be used for a variety of applications in coastal engineering.

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